

is considerably more arbitrary than its acceptance.

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### STANDARD PRINCIPLES, NONSTANDARD DATA, AND UNSOLVED ISSUES

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In their impressive article, Horne and Lowe (1996) reevaluate the theoretical import of stimulus equivalence. Their critical analysis seems largely correct. At one place, however, Horne and Lowe attribute the failure of equivalence explanations to the “artificial” character of match-to-sample procedures (Horne & Lowe, p. 238). In our view,

the fundamental problem with the equivalence framework stems less from its reliance on artificial situations than from a lack of clear theoretical principles (cf. Harzem, 1995<sup>1</sup>). Were such principles available, the artificiality of the procedures involved would not constitute a significant obstacle; after all, most behavioral concepts, including the concept of reinforcement used by Horne and Lowe, have been derived from experimental

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<sup>1</sup> Harzem, P. (1995, May). *Natural contingencies*. Paper presented at the annual meeting of the Association for Behavior Analysis, Washington, DC.

situations no less artificial than match to sample.

### *The Naming Account*

What processes, then, underlie *stimulus equivalence*? Horne and Lowe develop various possibilities, but not all of them seem equally important or relevant, and some are only partly specified. In the section entitled *Other Verbal Behavior and Stimulus Equivalence*, for example (Horne & Lowe, pp. 221–222), complex utterances such as “circle goes with the open triangle” are said to determine performance on equivalence tests. However, the utterances in question could not be emitted unless equivalence outcomes had already emerged; emitting “green means up” after up → green forward pairings, for example (Horne & Lowe, p. 221), assumes some form of symmetry in the first place because the names “up” and “green” appear in the utterance in a reversed order.

The core of the naming account can in fact be found in the section entitled *Intraverbal Naming and Stimulus Equivalence* (Horne & Lowe, pp. 218–221). A first mechanism explains [AB, AC]:BC effects, where AB and AC are trained relations and BC is the matching relation observed on testing. According to Horne and Lowe, AB and AC trials establish two verbal sequences, “ab” and “ac.” Over a mix of AB and AC trials, the name “a” tends to evoke “b” and “c” at once, which yields a new chain “b” → “c.” This chain mediates performance on BC testing: B → “b” → “c” → choose C. A second mechanism deals with symmetry or [AB]:BA effects. The AB trials establish the verbal sequence “ab.” Repeating this sequence subvocally, “ababab,” yields spontaneous “ba” reversals, which in turn establish the verbal chain “b” → “a.” This chain mediates performance on BA testing: B → “b” → “a” → choose A.

Thus, according to Horne and Lowe, it is the involvement of the subject’s internal speech that explains the discrepancies between traditional behavioral principles and human performance on equivalence tests. On the other hand, the behavior of nonverbal animals should generally conform to standard molecular Pavlovian and operant laws (Horne & Lowe, p. 223).

### *Implications of Nonhuman Data*

Numerous results, however, contradict this last aspect of Horne and Lowe’s position. Holland (1981), for example, exposed rats to AB pairings between a neutral stimulus (A) and food (B); in a second stage (AC), A was paired with a toxin (C). During testing, the rats displayed an “emergent” aversion to B, as if the food itself (B) had been paired with C. Urcuioli, Zentall, Jackson-Smith, and Steirn (1989, Experiment 2) obtained analogous results with matching to sample by pigeons; subjects exposed to BB, AB, and AC trials showed clear positive transfer on a BC matching task.

The point is not that such data demonstrate something called “stimulus equivalence,” but merely that they and the [AB, AC]:BC effects obtained in humans (Horne & Lowe, Figure 2, p. 188) raise similar problems for standard behavioral principles. Hence, these principles should be revised or else supplemented with internal mediation. Revising or abandoning standard principles would be incompatible with Horne and Lowe’s approach, which is after all almost entirely built on such principles, conceived as “behavioral primitives” (Horne & Lowe, p. 239); Horne and Lowe should therefore follow the second course, and this even for nonhuman subjects.

A mediational explanation of Holland’s (1981) data has in fact been proposed by Holland himself (1981, 1990). Events A, B, and C are supposed to evoke the internal representations *a*, *b*, and *c*, respectively (Holland, 1981, could rule out peripheral mediation as a plausible explanation of his results). First the AB pairings establish an internal chain *a* → *b*. The AC stage then allows *b* and *c* to occur together, which yields a new internal chain *b* → *c*. This produces the result observed on B testing: B → *b* → *c* → aversion. Holland’s model obviously parallels Horne and Lowe’s account of [AB, AC]:BC effects (see above). The [AB, BC]:AC transitivity results of monkeys (D’Amato, Salmon, Loukas, & Tomie, 1985) and pigeons (Kuno, Kitadate, & Iwamoto, 1994) could be explained along similar lines.

Other data raise doubts about Horne and Lowe’s picture of nonhuman behavior as being “locked” in forward relations (Horne &

Lowe, p. 223). With a transfer design, Hogan and Zentall (1977, Experiment III) did find some evidence for [AB]:BA effects in pigeons (see their Figure 5, p. 12), although the obtained effects were both transient and small in magnitude. Richards (1988, Experiments 2 and 3) also observed [AB]:BA transfer in pigeons with conditional discrimination tasks. The effects were small in magnitude, but persisted over sessions.

Recently Zentall, Sherburne, and Steirn (1992) found strong evidence for what they termed *backward associations* in pigeons' matching to sample. Subjects exposed to  $X \rightarrow A \rightarrow B$  trials, where  $X$  is a sample,  $A$  is a comparison, and  $B$  is some differential outcome (food or no food), showed clear transfer on a  $B \rightarrow A$  matching task (for a related effect in the budgerigar, see Manabe, Kawashima, & Staddon, 1995, Experiment 3). Zentall et al. (Experiment 3) showed that Pavlovian mediation involving the  $X$  samples probably did not underlie the observed effects, which thus took place solely at the level of the  $A$  and  $B$  stimuli.

Hearst (1989) similarly found strong [BA]:AB effects with pigeons in an autoshaping situation. Subjects exposed to BA pairings between food ( $B$ ) and a neutral stimulus ( $A$ ) showed clear positive transfer in a second stage of AB forward conditioning. The point is not that the pigeons showed backward conditioning; in fact, during the initial BA stage they virtually did not peck at Stimulus  $A$ . The point is rather that the pigeons showed [BA]:AB transfer.

Such data cannot be accounted for on the sole basis of strictly unidirectional principles of behavior. Besides, Horne and Lowe insist that the effects of common naming on equivalence class formation depend on the bidirectional nature of speaker-listener skills, as opposed to the mere establishment of a common response to different stimuli (Horne & Lowe, p. 225). But pigeons do tend to match stimuli that have previously been paired with the same outcome (Edwards, Jagielo, Zentall, & Hogan, 1982). Following Horne and Lowe's logic (Horne & Lowe, p. 225), one should therefore attribute internal echoic skills to pigeons.

And why not, indeed? With its reliance on the contiguities afforded by echoics to produce internal chains (" $b$ "  $\rightarrow$  " $a$ ," etc.), the

naming account closely parallels cognitive models of association based on covert rehearsal (e.g., Atkinson & Shiffrin, 1968). Because numerous data (e.g., Wagner, Rudy, & Whitlow, 1973) suggest the existence of rehearsal processes in nonhuman species, Horne and Lowe should be willing to extend their approach to the nonverbal mediators of nonhuman subjects (cf. Urcuioli, Zentall, & DeMarse, 1995). Backward associations in nonhumans would be attributed to the subjects' rehearsal of their own perceptual activities (Holland, 1990; Horne & Lowe, p. 194), just as the naming account attributes human [AB]:BA effects to the subjects' covert verbal echoics (see Wagner, 1981).

#### *Toward a Nonmediational Account*

Any explanatory framework that is incomplete or inadequate at the overt behavioral level can be made to fit numerous data by positing a variety of internal mediators. We believe, however, that as behavioral theory internalizes its terms, it becomes increasingly indistinguishable from cognitive psychology (see Rachlin, 1988; Schnaitter, 1987). A possible alternative to mediational accounts would be to formulate nonstandard behavioral principles at a molar level; although such an alternative remains to be developed, some properties of the relevant laws can be easily understood by reference to Holland's [AB, AC]:BC experiment (1981). The two stages of Holland's basic training paradigm appear as follows, where time flows from left to right: AB . . . . . AC. Neglecting the  $A$  stimuli, it is clear that Holland's procedure includes a molar sequence, .B . . . . . C, that differs from a standard BC pairing only in being more extended in time. From a molar viewpoint, the effect of the added  $A$  stimuli in Holland's experiment is to potentiate direct conditioning by this molar sequence (cf. Hineline, 1977, p. 397). Because this sequence is similar to a compact BC sequence (or pairing) in terms of internal composition, that it also results in a conditional response to  $B$  is not surprising.

A similar formulation could be applied to the AB and AC trials of match to sample. In addition, we suspect that the covert verbal activities postulated by Horne and Lowe could be replaced by molar sequences (Tonneau, 1990) including the past *overt* responses that

current mediators allegedly represent (see Rachlin, 1985). In the naming framework, after all, each internal response ("a") can be traced back to some prior overt behavior ("A").

Substituting combinations of molar sequences to chains of covert mediators, however, will require behavioral laws that are more complex than those assumed by Horne and Lowe. Adequate molar laws will probably incorporate response-independent forward and backward stimulus correlations (cf. Stemmer, 1973; Tonneau, 1993), consistent with numerous data showing the sensitivity of operant performance to Pavlovian relations (e.g., Davidson, Aparicio, & Rescorla, 1988; Ross & LoLordo, 1987). "Contingencies of reinforcement" may thus lose their basic status to become components of a broader causal system (see Malone, 1975; Pierce & Epling, 1984); our main concern with Horne and Lowe's approach is that it adheres to behavioral principles that are clearly in need of revision (Hinson, 1987; Malone, 1987).

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